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FAULTS

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Faults

Faulting is the visible surface feature of the tremendous forces within Earth's interior that cause earthquakes. Surface faulting usually arises from deep-seated movements of tectonic plates, large crustal slabs upon which the continents and oceans rest. Convective currents arising from the heated core cause these plates to move - spreading plates apart where heat from the core rises toward the surface and forcing plates together at plate margins. At first, a section of the crust may merely bend to a new position. Or slow movement known as fault creep may continue unhindered along a fault plane. But stresses often continue to build until they exceed the strength of the rock in that section of crust. The rock then breaks, and an earthquake occurs sometimes releasing massive amounts of energy. The ensuing earth displacement is known as a **fault**.

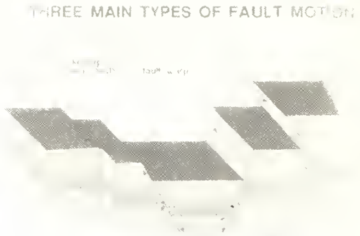
Vertical or horizontal movement may occur along a fault plane. Sometimes both vertical and horizontal movement occur simultaneously. Faults are named according to the type of movement that has occurred. When the vertical movement along the fault plane roughly matches the horizontal movement, the fault is called an **oblique-slip fault**. When the movement along the fault plane is generally horizontal, it is a **strike-slip fault**. These are also called **lateral faults**. A **left-lateral** fault is one in which the side opposite a person facing the fault has been displaced to the left, and a **right-lateral** fault is one in which the movement has been to the right. The cracking along a fault may be said to be **en echelon**, that is the cracks are off set like shingles on a roof when viewed from the side. A **transform** fault is a zone of lateral movement along which the ridges and rises have been off-set and along which the displacement suddenly stops or changes form and direction. Right lateral displacement occurs on the fault only between spreading areas and no displacement occurs outside of this.

When the movement along the fault plane is predominately vertical, it is a **dip-slip fault**. There are sub-classifications within this category. A **normal fault** occurs when the earth above the fracture moves down in respect to the earth below the fracture. A **reverse fault** occurs when the rocks above the fracture move up with respect to those below. A reverse fault with an angle of less than 45 degrees is called a **thrust** fault.

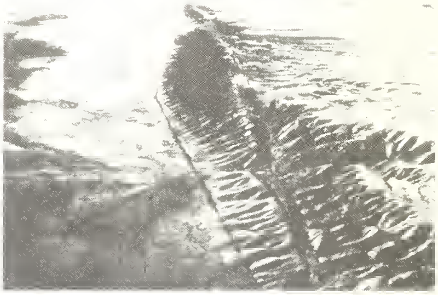
There are features in the landscape which are brought about by vertical faulting. A **scarp** is the upthrown side of a fault, i.e. where the block of earth has moved up exposing a fresh rock and soil face. A scarp resembles a low, linear cliff face. Because fault movement involves the sliding of one block past another, many fault surfaces are smoothly polished and grooved. These features, called **slickensides**, provide one clue to the direction of fault slippage of the most recent event. Miners obtaining mineral riches trapped along fault zones have given names to the two block sections on opposite sides of the vertical fault. The **footwall** is the block section beneath the miner's feet and the **hanging wall** is the section above his head.

Sometimes a section of Earth's crust is under pressure from horizontal forces in opposite directions. A **horst** is a long plateau or table-like formation, formed from a single elongated block which has been forced up under such pressure between two normal faults. When an area of the crust is being stretched apart, two normal faults may occur separated by a block of rock that falls into a lower position. This is called a **graben**. It is characterized by a long trough bounded by normal fault scarps on either side. Through the study of faults and their effects much can be learned about the size and reccurrence intervals of earthquakes and the movement of sections of Earth's crust that have produced mountains and changed continents.

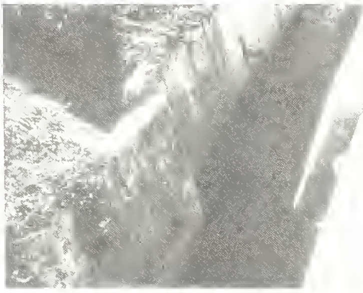
1 Diagram showing the three main types of fault motion. See description for more detailed information on the fault types.



2 The aerial view looks northwestward along the San Andreas fault in central California. The Carrizo Plain is on the left. The fault marks the major boundary between the Pacific and the North American tectonic plates, which are moving past one another at an average rate of about 2.5 cm per year. The San Andreas fault is known for its great length. It extends approximately 960 km from where it cuts the coast north of San Francisco until its several branches disappear beneath the waters of the Gulf of California. Photograph credit: National Geophysical Data Center.



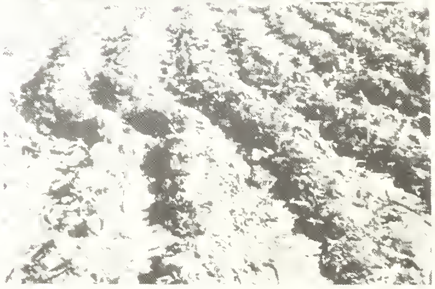
3 Drain offset produced by creep along the San Andreas fault at the Almaden Winery in central California. The winery is also experiencing offset walls, bent and broken pipes, etc. due to the fault creep. Motion along the fault is mostly strike slip. Photograph credit: University of California, Berekely.



4 The fence was offset 2.6 m by the magnitude 8.2 earthquake of April 18, 1906, San Francisco, California. The section of the San Andreas fault shown here is 0.8 km north of Woodville. The photo is looking northeast. The lateral or strike-slip fault offset is large; however, the trace is nearly invisible. This earthquake, together with the fire that followed, resulted in 700 deaths and 400 million dollars of property damage. Photograph credit: U.S. Geological Survey.

5 Two strike slip faults have broken and offset a ridge in the Frontier Formation, east of the Freezeout Hills in Wyoming. Photograph credit: Univ. of Colorado Geology Department (D. Eicher).

6 Rows in the cultivated field west of El Progresso, Guatemala, deformed by the earthquake of February 4, 1976. The thick, saturated, unconsolidated deposits have yielded by plastic deformation rather than rupture. This quake resulted in the deaths of 23,000 people and $1.1 billion dollars in property damage. Photograph credit: U.S. Geological Survey.



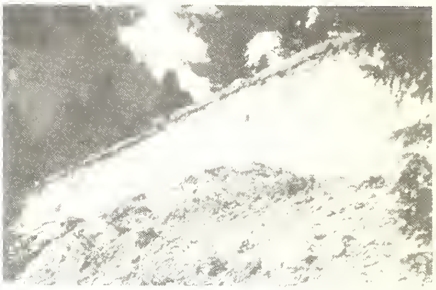
7 Aerial view along the Motagua fault trace northeast of Guatemala City, Guatemala, following the magnitude 7.5 earthquake of February 4, 1976. The fault goes from top to the bottom in the photograph and crosses the stream bed near the top of the photograph. The fault trace is marked by a zone less than 3 m wide of en echelon linear cracks with connecting short pressure ridges. There is an en echelon offset of several meters where the fault crosses the creek in the upper part of the slide. Note that the meandering creek does not follow the trace of the fault, which suggests that the fault rupture is geologically young at this locality. The Motagua fault is part of the transform fault system between the North American and Caribbean plates and comprises the northern boundary of the Caribbean plate. The American plate is moving 2.2 cm per year to the west along this boundary. The observed surface rupture along the Motagua fault was 320 km. Displacement across the fault was almost entirely horizontal with the strike-slip component ranging up to 340 cm and averaging 110 cm. Vertical displacements were less than 30 percent of the horizontal displacement. Photograph credit: U.S. Geological Survey.

8 Offset of a cement-lined ditch by a strike-slip or left-lateral fault resulting from the earthquake of February 4, 1976, in Guatemala. Faults caused extensive damage to underground facilities as well as surface structures. Photograph credit: U.S. Geological Survey.

9 This tree was killed by a strike-slip fault through its center from the earthquake of February 4, 1976. Photograph credit: U.S. Geological Survey.

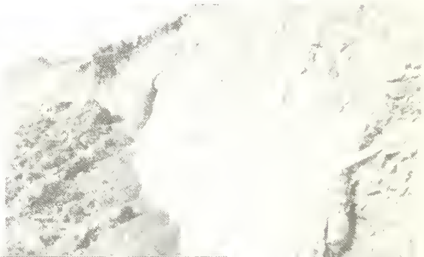
10 The Imperial fault east of El Centro, California, shows characteristic right stepping en echelon fractures. Rupture on the fault during the magnitude 6.9 earthquake of October 15, 1979, Imperial Valley, California, earthquake extended from about 4 km north of the international border to about 4 km south of Brawley. Maximum lateral displacement was about 55 cm in the Heber dunes, and maximum vertical displacement was 19 cm southeast of Brawley. The earthquake itself injured 19 people, damaged more than 2,000 homes and businesses in the Imperial Valley. Property damage was estimated at $30 million. Photograph credit: University of Colorado.

11 This fault scarp near Hebgen Lake, Montana, after the magnitude 7.1 earthquake of August 18, 1959, shows a dip-slip movement of 5.5-6 m. Since the earth above the fracture moved down in respect to the earth below the fracture, the fault is known as a normal fault. Maximum vertical displacement was 6.4 m observed near Red Canyon Creek. Considerable cracking and shifting of roadways and the destruction of much timber caused damage exceeding $11 million. In Yellowstone National Park new geysers started erupting, and large steaming cracks, resulting from massive slumping, were observed after the quake. Photograph credit: National Geophysical Data Center.



12 The magnitude 6.2 earthquake of October 28, 1983, near Borah Peak, Idaho, produced this fault. The scarp and fracture zone are located on Rock Creek, near Dickey, Idaho, and Doublesprings Pass Road. The wooden pole is 1.9 m high. This normal fault shows characteristics of oblique-slip, where there is both vertical and horizontal displacement. The horizontal movement is left lateral. The fault scarp extended for more than 35 km with vertical displacements up to 2.5 m observed between MacKay and Challis, Idaho. Photograph credit: U.S. Geological Survey (G. Reagor).

13 This section of the normal fault scarp produced by the earthquake of October 28, 1983, is 678.8 m northwest of the alluvial fan head on Rock Creek. Nearly vertical striae on the fault surface are visible on the lower half of the scarp. The scarp is 2.5 m high at this location. The earthquake killed two children in Challis and caused $12.5 million in property damage. Photograph credit: U.S. Geological Survey. (R.C. Bucknam)



14 The fault scarp from the earthquake of October 10, 1980, at El Asnam, Algeria, shows a 3-m vertical offset on a normal dip-slip fault. The scarp extends for kilometers along the landscape of El Asnam. This 7.3 magnitude earthquake killed 5,000 and caused severe damage. Photograph credit: Stanford University, (H. C. Shah).

15 Reverse fault in welded tuff in Mojave Desert, Death Valley area, California. Photograph credit: Univ. of Colorado Geology Department (B.Bradley).

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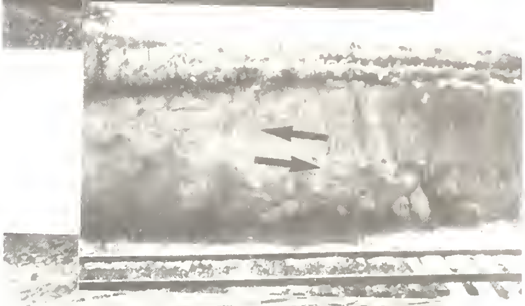
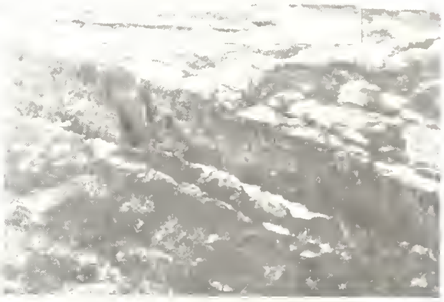
16 A small reverse fault in Prairie Bluff Chalk in the cut for the Alabama Great Southern Railroad in Sumter County, Alabama. Photograph credit: U.S. Geological Survey (W.H. Monroe)

17 Ripley Formation (to right) thrust from the south over the Prairie Bluff Chalk Formation on the east side of the tracks of the Alabama Great Southern Railroad. The fault plane dips 8° south. The fault is in Sumter County, Alabama. Photograph credit: U.S. Geological Survey (W.H. Monroe).



18 Small graben (down-dropped block) in tuff sedimentary beds in northern Nevada. Note two small offsets of darker red beds. Arrows mark faults. Photograph credit: Univ. of Colorado Geology Department (B. Bradley).

19 Aerial view of large fault zone and graben on west side of central rift zone at Thingvellir, Iceland. (Only one side of the graben is shown.) Iceland is on the mid-Atlantic ridge, a spreading zone. Grabens such as this one are typical of such spreading zones. View is looking west. Photograph credit: Univ. of Colorado Geology Department (B. Bradley).



20 Horst (uplifted) block in mid-Pliocene (5 million years old) volcanic rocks in the Warner Valley of southern Oregon. Photograph credit: Univ. of Colorado Geology Department (B.Bradley).

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